

1                                   **“DESANDING APPARATUS AND SYSTEM”**

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3                                   **CROSS REFERENCE TO RELATED APPLICATION**

4                   This application is a regular application of US Provisional application  
5 60/417,146 filed October 10, 2002 and of prior foreign applications namely,  
6 Canadian Patent Application 2,407,554 filed October 10, 2002 and Canadian Patent  
7 Application 2,433,741 filed June 27, 2003.

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9                                   **FIELD OF THE INVENTION**

10                  The present invention relates to a system and apparatus for the  
11 removal of particulates such as sand from fluid streams produced from a well while  
12 minimizing abrasion of the involved equipment.

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14                                  **BACKGROUND OF THE INVENTION**

15                  Production from wells in the oil and gas industry often contain  
16 particulates such as sand. These particulates could be part of the formation from  
17 which the hydrocarbon is being produced, introduced particulates from hydraulic  
18 fracturing or fluid loss material from drilling mud or fracturing fluids or from a phase  
19 change of produced hydrocarbons caused by changing conditions at the wellbore  
20 (Asphalt or wax formation). As the particulates are produced, problems occur due to  
21 abrasion, and plugging of production equipment. In a typical startup after stimulating  
22 a well by fracturing, the stimulated well may produce sand until the well has  
23 stabilized, often up to a month after production commences. Other wells may  
24 require extended use of the desander 10.

1           In the case of gas wells, fluid velocities can be high enough that the  
2 erosion of the production equipment is severe enough to cause catastrophic failure.  
3 High fluid stream velocities are typical and are even purposefully designed for  
4 elutriating particles up the well and to the surface. An erosive failure of this nature  
5 can become a serious safety and environmental issue for the well operator. A failure  
6 such as a breach of high pressure piping or equipment releases uncontrolled high  
7 velocity flow of fluid which is hazardous to service personnel. Release to the  
8 environment is damaging to the environment resulting in expensive cleanup and loss  
9 of production. Repair costs are also high.

10           In all cases, retention of particulates contaminates both surface  
11 equipment and the produced fluids and impairs the normal operation of the oil and  
12 gas gathering systems and process facilities.

13           In one prior art system, a pressurized tank ("P-Tank") is placed on the  
14 wellsite and the well is allowed to produce fluid and particulates. The fluid stream is  
15 produced from a wellhead and into a P-Tank until sand production ceases. The  
16 large size of the P-Tank usually restricts the maximum operating pressure of the  
17 vessel to something in the order of 1,000 – 2,100 kPa. In the case of a gas well, this  
18 requires some pressure control to be placed on the well to protect the P-Tank.  
19 Further, for a gas well, a pressure reduction usually is associated with an increase in  
20 gas velocity which in turn makes sand-laden wellhead effluent much more abrasive.  
21 Another problem associated with this type of desanding technique is that it is only a  
22 temporary solution. If the well continues to make sand, the solution becomes

1 prohibitively expensive. In most situations with this kind of temporary solution, the  
2 gas vapors are not conserved and sold as a commercial product.

3           An alternate known prior art system includes employing filters to  
4 remove particulates. A common design is to have a number of fiber-mesh filter bags  
5 placed inside a pressure vessel. The density of the filter bag fiber-mesh is matched  
6 to the anticipated size of the particulates. Filter bags are generally not effective in  
7 the removal of particulates in a multiphase conditions. Usually multiphase flow in  
8 the oil and gas operations is unstable. Large slugs of fluid followed by a gas mist is  
9 common. In these cases, the fiber bags become a cause a pressure drop and often  
10 fail due to the liquid flow therethrough. Due to the high chance of failure, filter bags  
11 may not be trusted to remove particulates in critical applications or where the flow  
12 parameters of a well are unknown. An additional problem with filter bags in most  
13 jurisdictions is the cost associated with disposal. The fiber-mesh filter bags are  
14 considered to be contaminated with hydrocarbons and must be disposed of in  
15 accordance to local environmental regulation.

16           Clearly there is a need for more versatile and cost effective system of  
17 particulate handling.

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## SUMMARY OF THE INVENTION

Desanding apparatus is provided which is placed adjacent to a well's wellhead for intercepting a fluid stream flow before prior to entry to equipment including piping, separators, valves, chokes and downstream equipment. The fluid stream can contain a variety of phases including liquid, gas and solids.

In one embodiment, a pressure vessel is inserted in the flowstream by insertion into high velocity field piping extending from the wellhead. The vessel contains an upper freeboard portion having a cross-sectional area which is greater than that of the field piping from whence the fluid stream emanates. As a result, fluid stream velocity drops and particulates cannot be maintained in suspension. A cross-sectional area of the freeboard portion is maintained through a downcomer flow barrier adjacent the vessel's exit.

In a broad aspect, desanding apparatus vessel for removal of particulates from a fluid stream containing particulates comprises: a fluid inlet adjacent a first end of the vessel and adapted for receiving the fluid stream, the fluid inlet discharging the fluid stream at an inlet velocity into a freeboard portion at a top of the vessel, the fluid stream in the freeboard portion having an elutriation velocity less than the inlet velocity and such that contained particulates have a fall trajectory; a fluid outlet from the vessel, the outlet being spaced horizontally from the inlet; and a flow barrier depending from the top of the vessel and having a lower edge so as to direct the fluid stream below the barrier before discharge from the outlet port for maintaining the freeboard portion above the lower edge and forming a belly storage portion below the lower edge, the flow barrier being positioned between the fluid inlet

1 and fluid outlet and the flow barrier being spaced from the fluid inlet so as to enable  
2 the fall trajectory of a substantial amount of the particulates to intersect the belly  
3 portion so as accumulate particulates in the belly portion prior to the flow barrier  
4 wherein the fluid stream at the fluid outlet is substantially free of particulates.

5 Preferably, the flow barrier is a depending weir independent of the  
6 outlet, or could be formed by the outlet itself. A cleanout port is preferably included  
7 for periodic removal of accumulations of particulates.

8 More preferably, a vessel of an embodiment of the present invention is  
9 incorporated in a desanding system to replace existing prior connective piping, the  
10 vessel being supported using structure to align the vessel with the wellhead piping  
11 and downstream equipment.

1                                    BRIEF DESCRIPTION OF THE DRAWINGS

2                                    Figure 1a is a schematic arrangement of connective wellsite piping of  
3 the prior art;

4                                    Figure 1b is a schematic arrangement of one embodiment of the  
5 invention having been installed in place of the prior connective wellsite piping of Fig.  
6 1a;

7                                    Figure 2a is an exploded view of the inlet to one embodiment of the  
8 vessel of the invention which illustrates a nozzle arrangement in an eccentric vessel  
9 inlet;

10                                  Figure 2b is an exploded view of the inlet to one embodiment of the  
11 vessel of the invention which illustrates a nozzle arrangement adapted to a blind  
12 flange;

13                                  Figure 3 is a cross-sectional side view of one embodiment of the  
14 invention illustrating fluid streams, falling trajectory of particulates, and  
15 accumulations of separated liquid, particulates and particulate-free fluid discharge;

16                                  Figures 4a through 4c illustrate a variety of optional flow barriers  
17 applied at the fluid outlet; and

18                                  Figure 5 is a performance graph of the achievable gas throughout  
19 rates at various pressures while still achieving particulate removal for a pessimistic  
20 case of a fluid stream containing fine 100 mesh sand.

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## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown in Figs. 1b and 3, a desander 10 comprises a substantially horizontal, cylindrical pressure vessel 11 having a first fluid inlet end 12 adapted for connection to a fluid stream F such as from wellhead piping 9 and a fluid outlet 13 connected to downstream equipment 14 such as multiphase separators. The fluid stream F typically comprises a variety of phases including gas G, some liquid L and entrained particulates such as sand S. The fluid stream emanating from the fluid outlet 13 is typically liquid L and gas G, with a substantial portion of the particulates S being captured by the desander 10. As a system, the desander 10 is typically inserted as a replacement for existing piping 15 (shown in Fig. 1a). The desander 10 is preferably supported with structure 16 such as elevation adjustable jacks to align the desander 10 relative to the existing wellhead piping 9 and downstream equipment 14.

With reference to Figs. 2a and 2b, the inlet 12 is fitted with a first connector or inlet flange 20 so as to better facilitate installation, to allow easy inspection for wear, to minimize equipment erosion and to simplify replacement when erosion has reduced material thicknesses to acceptable minimums. A nozzle 21 and a second connector or a nozzle flange 22 are adapted for complementary and sealed connection to the inlet flange 20. Typically, the nozzle 21 has a threaded inlet 23 which is adapted for threaded connection to an existing coupling 24 from the wellhead piping 9. The nozzle inlet 23 is threaded onto the coupling 24 and the vessel and inlet 12 is positioned over the nozzle 21 and the flanges 20,22 are connected.

1                   In greater detail as shown in Figs. 2a,2b and 3, the nozzle 21 has a  
2 protruding discharge portion 25 which extends adjacent the top of the vessel 11.  
3 The inlet 12 is offset upwardly from an axis A of the vessel 11 and extends into an  
4 upper freeboard portion 30. Preferably, as shown in Fig. 2a, an eccentric fitting 31 is  
5 applied to the inlet 12. When coupled with the inlet flange 20 on the eccentric fitting  
6 31, the nozzle 21 is shifted upwardly from an axis A of the vessel 11. Similarly, as  
7 shown in Fig. 2b, the nozzle 21 can extend through a large blind inlet flange 20 fit  
8 directly to the vessel 11 positioned so as to be shifted upwardly from an axis A of the  
9 vessel 11. The nozzle 21 discharges the fluid stream F along the nozzle's axis, a  
10 path P, substantially parallel to the vessel's axis A. The nozzle inlet 23 is typically  
11 formed of heavy-wall piping to extend its operational life in the abrasive environment  
12 of the particulate laden fluid stream F. Further, the nozzle's discharge 25 protrudes  
13 into the vessel 11 sufficiently to extend beyond the inlet 12 and into the freeboard  
14 portion 30, thereby aiding in minimizing localized wear on the less easily replaced  
15 inlet 12, or eccentric fitting 31, of the vessel 11

16                   In Fig. 3, the desander 10 further comprises belly portion 32, formed  
17 below the freeboard portion 30, for receiving and temporarily storing liquids L and  
18 sand S which separate from the fluid stream F. The fluid stream F containing sand  
19 S enters through the inlet 12 and is received by a larger cross-sectional area and  
20 substantially gas-phase volume of the freeboard portion 30. Accordingly, the  
21 velocity of the fluid stream F slows to a point below the entrainment or elutriation  
22 velocity of at least a portion of the particulates S in the fluid stream. Those of skill in  
23 the art are able to determine and apply the parameters of the fluid stream F, fluid



1 stream velocity and those of the particulates S so as to determine the elutriation  
2 characteristics. As the area of the freeboard portion 30 increases, the velocity of the  
3 fluid stream F slows and a lesser fraction of the particulates remain entrained; a  
4 greater fraction of particulates S falling out of suspension from the fluid stream F.  
5 The particulates S are discharged horizontally from the nozzle 21 along path P, and  
6 as they fall from suspension, they adopt a downwardly curved trajectory under the  
7 influence of gravity. Preferably, to avoid impingement-type erosion, the length of the  
8 vessel is sufficient to permit the particulates to fall out of suspension before  
9 impinging internals of the vessel 11. Given sufficient horizontal distance without  
10 interference, the particulates S eventually fall from the freeboard portion 30 and the  
11 trajectory intersects with the belly portion 32. The particulates S deposit and  
12 accumulate over time in the belly portion 32. Typically, liquids L from the fluid  
13 stream also collect in the vessel's belly portion 32.

14           The freeboard portion 30 is maintained using means such as a  
15 depending flow barrier 40 to ensure that the collected liquids L and particulates S  
16 only reach a maximum depth in the belly portion 32 of the vessel 11. A minimum  
17 cross-section area of the freeboard portion and preferred length of the freeboard  
18 portion 30 are determinable based on the elutriation characteristics and are  
19 established so as to maximize release of the particulates S before they reach the  
20 outlet 13. The greater the length or spacing between the inlet 12 and the flow barrier  
21 40, the greater is the opportunity to drop and release entrained particulates S.

22           Typically, liquid L out of the fluid stream F accumulates in the belly  
23 portion 32 to a steady state level and then is re-entrained for discharge with fluids

1 exiting the outlet 13 without affecting the capability of the vessel 11 and belly portion  
2 32 to continue to accumulate particulates S. Regardless of dropout of liquids L from  
3 gas G and collection of liquid L in the vessel 11, this upper freeboard portion 30  
4 remains substantially gas-filled. However, should a maximum depth of particulates  
5 S be reached during operation and encroach on the freeboard portion 30, operations  
6 may yet continue as if the vessel 11 were not even installed; both incoming liquid L  
7 and particulates S being temporarily re-entrained with the fluid stream flowing from  
8 the vessel outlet 13 until the earliest opportunity to perform maintenance. Typically  
9 the belly portion 32 vessel 11 is periodically cleaned out or emptied of accumulated  
10 particulates and liquid at sufficient intervals to ensure that the maximum  
11 accumulated depth does not encroach on the freeboard portion 30. Maintenance  
12 and operations personnel are further able to physically view sand production  
13 volumes during the cleanout and inspection.

14               The flow barrier 40 depends downwardly from the top of the vessel 11.  
15 The flow barrier 40 has a lower edge 41 which sets the maximum depth of the belly  
16 portion 32. As discussed above, the flow barrier 40 is preferably spaced sufficiently  
17 from the inlet 11 to enable the fall trajectory of the particles to intersect the belly  
18 portion 32 before impinging on the flow barrier 40 itself.

19               As shown in Figs. 4a-4c, the flow barrier 40 can comprise a discrete or  
20 separate plate 40a,40b as shown in Figs. 4a and 4b, spaced from the outlet 13, or  
21 as shown in Fig. 4c, a flow barrier 40c can be formed by the outlet 13 itself. All of  
22 the various flow barriers 40,40a,40b,40c have a lower edge 41 which forces the fluid  
23 stream S thereunder before discharging from the vessel 11 at outlet 13.

1 Accumulated levels L,S encroaching above the lower edge 41 will result in high  
2 velocities and re-entrainment of liquids L and particulates S from the area about the  
3 flow barrier 40, inherently resulting in a steady state maximum level of accumulation  
4 of the belly portion 32.

5 In the embodiment shown in some detail in Fig. 4c, the outlet 13 itself  
6 acts as the flow barrier 40, which incorporates a tubular portion 43 protruding  
7 downwardly and depending through the freeboard portion 30. The tubular portion 43  
8 also has a lower edge 41 spaced from the top of the vessel 11 which forces the fluid  
9 stream F to exit from a point nearer the vessel axis A. Particulate-free fluid, typically  
10 being gas G and some liquid L, is collected about the axis A for discharge through  
11 the discharge tubing 40 and outlet 13. An advantage of providing a separate flow  
12 barrier 40,40a,40b is that any abrasion and erosion is borne by the barrier 40 and  
13 not by the outlet's 13 tubular portion 43.

14 As shown in Figs 4a,4c, the outlet 13 for the vessel 10 is preferably  
15 arranged perpendicular to the axis A of the vessel 10 for further inertial rejection of  
16 re-entrained particulates S.

17 Referring once again to Fig. 3, a quick release pressure-vessel  
18 compatible cleanout 50 is provided for access to the vessel 11 for cleanout of the  
19 accumulated particulates. The vessel must be depressurized before opening and  
20 cleaning out particulates. Typically, mechanically-interlocked safety means 51 are  
21 provided so that the vessel must be de-pressurized before the cleanout can be  
22 opened. For de-pressurization, the vessel is isolated from the fluid stream F and  
23 pressure is bled off from the freeboard portion 30 until the cleanout 50 be removed.

1 As shown in Fig. 1b, a catch basin 52 or other suitable collection means is provided  
2 for accepting the collected liquid L and particulates S. Manual cleanout is performed  
3 although automated cleanout could be incorporated without diverging from the intent  
4 of the invention.

5

## 6 EXAMPLES

7 A typical vessel according to the present invention, and for reference  
8 are roughly approximated by the proportions of Fig. 3, can be a 6" or an 8" diameter.  
9 Using an 8" diameter, schedule 160 shell for the vessel 11 can result in a fluid  
10 stream capacity of about 8 million cubic feet of gas per day. A 2" schedule 160 inlet  
11 nozzle extends about 1" beyond an eccentric inlet 12 and into the vessel 11. With a  
12 flow barrier 40 placed about 8 feet from the nozzle discharge 25, the desander 10  
13 achieved a corresponding and typical collection rate of 1.5 gallons of sand  
14 particulates per day, determined in a worst case scenario of particles of about 100  
15 mesh. Applied to problem wells in several exceptional cases, using no vessel at all,  
16 one prior art wellhead, piping and equipment experienced four breaches and in  
17 another case, seven breaches. After installation of a preferred vessel of the present  
18 invention, no further breaches were experienced. In one case, the resulting  
19 collection of particulates, as sand, was about 5 liters per day.

20 Further, as shown in Fig. 5, the throughput capability of 8 inch and 10  
21 inch diameter desanding vessels are illustrated for a variety of fluid pressures.

22 A system incorporating a desanding apparatus according to one of the  
23 embodiments disclosed herein will benefit from advantages including: As a

1 desander 10 is more cost effective than a "P Tank", the desander can be  
2 economically placed on a wellsite for long term sand protection (substantially  
3 permanent as required); with a pressure rating that allows the vessel to operate at  
4 the wellhead conditions, minimal pressure drop is experienced across the vessel;  
5 the desander is designed to exceed ASME code for pressure vessels; sand is  
6 removed from the fluid stream without erosive effects on the operator's downstream  
7 equipment and; as the vessel is passive, having no moving parts, plugging from  
8 particulates is not an issue; sand can be removed simply and mechanically from the  
9 vessel at regular intervals; by removing the sand prior to it entering the producing  
10 system, contamination of equipment and produced fluids is avoided; and the  
11 desander is capable of handling multiphase production and has demonstrated an  
12 ability to remove sand from both gas and oil streams. This results in a wider  
13 application than prior art filter methods.